

three branchial arches of the mackerel, however, bear no long teeth, but an outer and inner series of tubercles with spines. By means of this latticework of teeth and spines the mackerel, like the herring, can easily filter great masses of Copepods from the water. According to A. Boeckh (Forhandl. Vid. Selsk. Christ. 1864, p. 227), the autumn mackerel on the Norwegian coast become fattened by abundant Copepod nourishment. On the east coast of Schleswig and Holstein the mackerel appears in considerable quantities only from the beginning of July to the end of September; from autumn to spring therefore, when the shoals of sprats and herrings appear here, the mackerel does not deprive them of any of their best food.

Where multitudes of food-animals occur, there also, as a general rule, multitudes of fishes collect. The herrings pursue the Copepods; and the cod (*Gadus morrhua*) follow the herrings. For a long time there had not been so many large cod taken between the fortress of Friedrichsort and the village of Labö as in the winter of 1871–72, when the herrings were so plentiful.

For carrying on the fishery, such a gathering together of great shoals of fishes belonging to the same species is of great value. Social animals of the same kind lead a similar life. They seek their food in common, become sexually mature at the same time, and collect, for the purpose of spawning, at definite spots. Thus the fisherman finds them at certain times in great numbers together, and can reckon beforehand on making a good haul with properly designed instruments of capture. But where many different species live, the fisherman cannot take an equal weight of fish with the same amount of labour, even when the sum of all the individuals in the same space is as great as the number of individuals of a single species, because each different species has a different nature, and consequently must be circumvented in a different manner. Hence, whilst the rich southern fish-fauna breaks up the work of the fishing-population and renders it less remunerative, the northern fish-fauna, which, although poorer in species, is rich in individuals, leads to a powerful and remunerative concentration of the business of fishery.

XI.—On some new Species of Stromatopora. By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.E., &c., Professor of Natural History in University College, Toronto.

[Plate IV.]

THE affinities of the singular genus *Stromatopora* have always been more or less uncertain, though there has been a general

tendency to regard the genus as being referable either to the Foraminifera or to the sponges, or as constituting a connecting link between these two orders of Rhizopoda. In the present communication I propose to describe four new species of the genus from the Silurian and Devonian formations of Western Canada, all of which show certain points of relationship to the Spongiida which have not been noticed in the species already recorded by palæontologists.

1. *Stromatopora ostiolata*, Nich. Pl. IV. figs. 1, 1 a.

Spec. char. Fossil forming large hemispherical masses, several inches in diameter, composed of innumerable delicate laminae, arranged concentrically, and separated by interspaces which are broken up by numerous slender vertical pillars, giving the whole a finely reticulate structure. The laminae are as thin as writing-paper; and, with the intervening interspaces, there are about ten of them in the space of one line. The upper surface of the mass is undulated and is quite smooth, except for the presence of small rounded or conical elevations, perforated at the apex with rounded openings (Pl. IV. fig. 1 a) and arranged with tolerable regularity in diagonal lines. These elevations have a width of about half a line, and appear to be of the nature of exhalant apertures or oscula. The lines of oscula are placed at distances apart of from four to five lines; and the oscula in each line are about the same distance from one another. When the mass is broken, similar osculiferous surfaces are found to exist throughout the whole, arranged concentrically with one another, and separated by spaces varying from two to three lines in thickness, these spaces being occupied by the ordinary laminated or reticulated tissue of the fossil. Laterally the laminae and osculiferous surfaces, instead of being concentrically arranged as regards the entire mass, terminate in a series of rounded, nipple-shaped prominences, each of which is composed of thin concentric laminae which scale off like the coats of an onion. The lateral surfaces of the fossil thus come to exhibit an extraordinary nodulated and botryoidal appearance (Pl. IV. fig. 1).

It is impossible to give in a few words any adequate diagnosis of this most remarkable fossil, which appears to throw considerable light upon the affinities of the genus *Stromatopora*, if, indeed, it does not truly constitute a new genus. In the fact that its main bulk consists of a succession of thin calcareous laminae, with intermediate vertical props, pillars, or dissepiments, marking off minute cellular compartments, *S. ostiolata* agrees entirely with the typical species of *Stromatopora*; and in the great number of laminae in a given space it closely

resembles *S. striatella*, D'Orb. It exhibits, however, two peculiarities which, so far as I am aware, are altogether unique.

In the first place, it is not composed, as are *S. striatella*, D'Orb., and *S. concentrica*, Goldf. (which it most nearly resembles in general form), of a succession of laminae concentrically arranged round an imaginary centre or centres. On the contrary, in the present species, intercalated amongst the general enveloping concentric laminae of the mass is a series of cylindrical masses, each composed of laminae concentric with its long axis, and each terminating (probably at both ends, though this is not shown) in a rounded nipple-shaped extremity. Superiorly these laminated cylinders are enveloped by laminae which are concentric to the whole mass, so that the outermost surface is simply undulating. On two of the sides of the fossil the ends of the above-mentioned cylinders protrude as so many nipple-shaped conical prominences, giving these aspects of the mass very much the appearance of the peculiar inorganic structure known as "cone-in-cone."

In the second place, a still more remarkable feature is presented by the upper surface of the fossil. The specimens are so highly mineralized (as is always the case with the fossils of the dolomites of the Guelph formation) that the smooth undulating upper surfaces of the laminae exhibit no structure that can be made out with the lens. If any pores existed, as is most probable, they cannot now be detected. The upper surface, however, exhibits tolerably regular diagonal lines of small conical papillae, some of which at any rate are unmistakably perforated by rounded apertures. It is true that some of these eminences do not show any sign of being perforated; but this is probably, indeed almost certainly, due to the peculiar condition of mineralization of the fossil. The perforated eminences are distant from two to four lines from one another; and the diagonal rows stand about as far apart. The appearance presented by the upper surface, with its perforated papillae, thus comes to simulate somewhat the root of a fossil plant like *Stigmaria*, with the points whence the rootlets proceeded. The eminences themselves are but slightly elevated above the general surface; and the apical aperture has a diameter of about one thirtieth of an inch. Not only does the outermost or highest lamina of the fossil exhibit the above appearance, but the same structure reappears at intervals of two to three lines all through the mass, each surface being concentric with the preceding one, and separated from it by reticulated tissue. It is probable, therefore, that we should regard the fossil as really consisting of thin crusts, which are only accidentally superimposed one above the other.

A structure apparently analogous to the above has been described (M'Coy, Pal. Foss. pp. 12 & 65) as occurring in *Stromatopora striatella*, D'Orb., *S. concentrica*, Goldf., and *S. (Caunopora) placenta*, Phill. In the first of these, according to M'Coy, the general laminated structure of the mass is traversed nearly at right angles by "vertical vermicular perforations about one fourth of a line in diameter," at distances varying from one to two lines apart; and essentially the same thing is seen in the other two species above mentioned. In the present species, however, there is no evidence that the apertures on the surfaces of the successive osculiferous layers communicate internally with vermicular tubes, though it is possible that they do; whilst the apertures are placed at the summit of small rounded or conical elevations, and are comparatively remote and large.

It can hardly be doubted that the perforated eminences of *Stromatopora ostiolata* correspond with the "oscula" of the genuine sponges. Indeed the surface of this species reminds one very strongly of the well-known genus *Porospongia* or *Manon*. The probability that *Stromatopora* is truly referable to the Calcispongiæ is thus rendered stronger than it would have appeared from the evidence formerly in our possession. If, however, it should be found that these oscula are not present in all the species at present referred to *Stromatopora* (and they have certainly not hitherto been recognized in the majority of forms), then it might be advisable to divide the genus into two, retaining *Stromatopora* for the species without oscules, and forming a fresh genus for those in which these apertures are present. The former would thus be nearly allied to the Foraminifera, whilst the latter would lead from the Foraminifera to the Calcispongiæ.

The specimens of *Stromatopora ostiolata* from which the above description was taken were presented to the Museum of the University of Toronto by their discoverer, Mr. John Wilkie. The species itself cannot possibly be confounded with any previously described form.

Loc. and Form. In the yellow crystalline dolomite of the Guelph formation (Middle Silurian), Guelph, Ontario. Associated with numerous specimens of *Stromatopora concentrica*, Goldf.

2. *Stromatopora tuberculata*, Nich. Pl. IV. figs. 2, 2 a.

Spec. char. Fossil forming crusts of varying thickness and often covering large surfaces, composed of numerous concentric calcareous laminae, separated by delicate calcareous rods or

pillars, which are disposed at right angles to the laminæ and mark off minute cellular compartments or interspaces. The laminæ and intervening spaces are about five in the space of a line; and the vertical pillars are comparatively strong, and placed at proportionally remote intervals. The upper surface of the mass (Pl. IV. fig. 2) is more or less strongly undulated, and is covered with close-set, conical, clavate, or fungiform tubercles, the elevation of which is about one twenty-fifth of an inch above the general surface. The tubercles appear to be sometimes perforated, but are more commonly imperforate, and they are placed in irregular sinuous lines. They are separated from one another by about their own width (more or less), one twenty-fifth of an inch. Where this fossil is broken it is seen that similar tuberculated surfaces occur at various depths in the mass, concentric with one another, and separated by laminated and reticulated tissue.

This singular species is readily distinguished by its very coarse reticulation (coarser than in any other species of *Stromatopora* with which I am acquainted), and by the tuberculated nature of the surface. There is no proof that the vertical pillars which separate the different laminæ of the mass are hollow; and there is reason to believe that they are certainly solid. As a rule, also, no perforations can be detected in the surface-tubercles; and the true nature of the latter is thus rendered a matter of question. In some specimens, however, the tubercles appear to be distinctly perforated at their apices. Many examples exhibit rounded openings or tubes, from half a line to a line in diameter, descending at right angles to the mass, and placed at varying intervals. These openings are not elevated above the general surface. They are not constant in their occurrence, though very generally present; and I have not been able to satisfy myself that they are not truly extraneous to the fossil. They may, perhaps, be annelidous in their nature; or they may be due to the fact that the organism has enveloped a colony of *Syringopora*, which has subsequently been dissolved away. In one specimen the crust seems to have been supported upon a wrinkled calcareous base, very similar to the epitheca of *Favosites gothlandica*. The crusts vary in thickness from three or four lines to two inches or more; but the latter specimens are to be regarded as being composed of a succession of crusts superimposed, the younger upon the older.

Loc. and Form. Common in a silicified condition in the Corniferous Limestone (Devonian) of Ridgeway and Port Colborne, on the north shore of Lake Erie, Canada West. Collected by the author.

3. *Stromatopora granulata*, Nich. Pl. IV. figs. 3, 3 a.

Spec. char. Fossil forming thin crusts (usually about half an inch in thickness), often occupying very extensive surfaces. Composed of concentric calcareous laminæ, about ten in the space of a line, separated by interspaces which are minutely broken up into cells by numerous delicate vertical rods. Surface regularly undulating, often raised into chimney-like or conical elevations, which, however, are never perforated. The entire surface is covered with a fine miliary granulation, constituted by minute conical pustules, placed close together, about one hundredth of an inch apart, and apparently imperforate. Exfoliated and broken specimens show that similar granulated surfaces occur at small intervals throughout the crust.

Stromatopora granulata is nearly allied to *S. tuberculata*, from which, however, it can be readily separated, even in small fragments. It is recognized by the much finer reticulation of the laminæ and vertical rods (Pl. IV. fig. 3 a), and by the minute crowded tubercles which cover the whole surface being so closely placed as to be often nearly in contact. Though many of the specimens show larger or smaller crateriform elevations, I have been unable to detect any perforations or apertures in the surface. Usually the surface-layers exfoliate round numerous points, giving the upper surface of the fossil quite a characteristic appearance, which is wanting in *S. tuberculata*. One specimen observed by me covered a slab about three feet in length by two feet in width, with an average thickness of about half an inch.

Loc. and Form. Not uncommon in a silicified condition in the Corniferous Limestone (Devonian) of Port Colborne and Savage's Quarry, Wainfleet, on the north shore of Lake Erie, Canada West. Collected by the author.

4. *Stromatopora mammillata*, Nich. Pl. IV. fig. 4.

Spec. char. Fossil forming thin crusts, about two or three lines in thickness, often covering extensive surfaces. Crust composed of successive concentric calcareous laminæ, separated by interspaces, broken up by vertical rods. Surface undulating, and exhibiting a series of large conical elevations, about one fifth of an inch in height and the same in diameter at the base, placed at distances apart varying from one fifth of an inch to half an inch. Most of these conical elevations show no signs of being perforated; but some appear to have apertures at their summits. The surface between these elevations is roughened by small tubercles and irregular ridges.

Nothing could be more distinct than the aspect of this very

remarkable species, the large conical elevations which cover its surface giving it exactly the appearance of an undulating plain covered with numerous small volcanos. Superficially examined, it presents a striking resemblance to many recent sponges; but I have not been able to satisfy myself that the conical elevations just alluded to are really of the nature of oscula. Some of them certainly look as if they were perforated; but most show no signs of any aperture. This may be due to the manner in which the fossil has been preserved; but I cannot speak positively upon this point. The internal structure of all the examples which I possess of this species is much more imperfectly preserved than is the case with the other species here described, and I have simply been able to satisfy myself that it is essentially the same as is characteristic of *Stromatopora* in general. I have seen crusts of this species covering an area of several square feet; but it is by no means common in its occurrence.

Loc. and Form. Rare, in a silicified condition, in the Corniferous Limestone (Devonian) of Port Colborne, on the north shore of Lake Erie, Canada West. Collected by the author.

5. *Stromatopora concentrica*, Goldf.

Besides the preceding three species I have found in the Corniferous limestone of Canada specimens which are undistinguishable from *Stromatopora concentrica*, Goldfuss. As, however, none of these specimens exhibit their surface it cannot be positively asserted that they belong to this familiar Devonian species.

EXPLANATION OF PLATE IV.

Fig. 1. Fragment of *Stromatopora ostiolata*, Nich., natural size.

Fig. 1 a. Fragment of the same, enlarged, to show the oscula on the surface.

Fig. 2. Fragment of *Stromatopora tuberculata*, Nich., natural size.

Fig. 2 a. Lateral view of a fragment of the same, enlarged, to show the reticulate structure.

Fig. 3. Fragment of *Stromatopora granulata*, Nich., natural size, showing the granulated surface.

Fig. 3 a. Lateral view of a fragment of the same, enlarged to show the reticulate structure.

Fig. 4. Fragment of *Stromatopora mammillata*, Nich., natural size.

XII.—*A Sphæromid from Australia, and Arcturidæ from South Africa.* By the Rev. THOMAS R. R. STEBBING, M.A.

[Plate III. A. figs. 1-3 a.]

THE crustaceans described in this paper presented themselves among the sand and fragments shaken in transit from a variety